# OPERATOR'S MANUAL

## MODEL 7016
## ELECTRONIC FREQUENCY COUNTER-TIMER

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Figure 1-1. Model 7016 Electronic Frequency Counter-Timer

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**WARNING**

**The Model 7016 is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to follow directions can result in a serious or fatal accident.**

**SHOCK HAZARD:** As defined in American National Standard, C39.5, Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, a shock hazard shall be considered to exist at any part involving a potential in excess of 30 volts RMS or 42.4 volts DC or peak and where a leakage current from that part to ground exceeds 0.5 milliampere, when measured with an appropriate measuring instrument defined in Section 11.6.1 of ANSI C39.5.

(NOTE: The proper measuring instrument for the measurement of leakage current consists essentially of a network of a 1500 ohm non-inductive resistor shunted by a 0.15 microfarad capacitor connected between the terminals of the measuring instrument. The leakage current is that portion of the current that flows through the resistor. The Simpson Model 229-Series 2 AC Leakage Current Tester meets the ANSI C39.5 requirements for the measurement of AC leakage current and can be used for this purpose. To measure DC Leakage current, connect a 1500 ohm non-inductive resistor in series with a Simpson 0-500 DC microammeter and use this as the measuring instrument.)

# SECTION I

# INTRODUCTION

## 1.1 GENERAL

The Simpson Model 7016 Frequency Counter-Timer (hereafter referred to as Model 7016, or the Instrument), is a highly accurate, versatile frequency counter-timer suitable for use in laboratory, production, servicing, and in digital systems for industrial controls. Specifically, the Model 7016 (see Figure 1-1), is intended for any use where frequencies, elapsed time or events are to be measured. The Instrument provides direct counting capability from 5 Hz to in excess of 50 MHz. When interfaced with a high frequency prescaler such as the Simpson Model 7020, the Model 7016 counting capability is extended to high frequency signals in excess of 500 MHz. For other applications, see paragraph 4.7 of this manual. The Model 7016A, which has an internal oscillator accuracy of 1 PPM, can be ordered as an option. The Model 7016B, which has a BCD output, is also available as an option.

## 1.2 DESCRIPTION

**1.2.1** This highly accurate Instrument features an overrange capability which provides up to nine-digit resolution in frequency measurements. Maximum reliability, with a minimum number of components, is achieved by using monolithic integrated circuits. The Instrument maintains its rated accuracy over a wide temperature range and line voltage variations. More accurate measurements can be achieved by connecting an external precision oscillator to the rear panel BNC connector which is a standard feature of the Instrument. Other standard features include: 0.55 inch planar gas-discharge display, display storage selection, automatic decimal point location, variable display time, manual reset, overrange and gate time indications; high input impedance, and input overload protection. This Instrument can operate with a line voltage of either 120V AC or 240V AC, 50, 60, and 400 Hz (see Section II, Figure 2-1).

**1.2.2** The Counter-Timer provides numerical displays of:

a. Average frequencies from 5 Hz to 50 MHz in four ranges.
b. Elapsed time from 0.01 sec. to 19999.99 sec, with either front or remote control.
c. Totalizing, with either front panel or remote control

**1.2.3** Components in the counter-timer have been placed for ease of maintenance and increased instrument ruggedness. Except for the power transformer and panel controls, all circuit components are mounted on only two printed circuit boards for both instrument reliability and access to test points. The numerical display is mounted on a plug-in P.C. board for easy servicing. Ambient lighting effects are minimized by a filter which reduces reflections and background illumination. With simplified switch and control nomenclatures, operator errors are reduced to a minimum. Personnel with no experience with an instrument of this type can obtain quick and accurate measurements with minimum training.

## 1.3 ACCESSORIES AND SUPPLIES

All supplies and accessories required for the operation of the Electronic Frequency Counter-Timer are furnished with each Instrument, and listed in Table 7-1. Other accessories available are listed in Table 7-2.

## 1.4 TECHNICAL DATA

Table 1-1 lists the technical data for the Simpson Models 7016 and 7016A (optional).

## 1.5 OPTIONAL INSTRUMENTS

**1.5.1** Model 7016A High Accuracy Electronic Frequency Counter-Timer (Catalog No. 22972) is identical to Model 7016, except it has a more accurate and stable internal oscillator (1 ppm). See item 6 of Table 1-1 for detailed specifications.

**1.5.2** Model 7016B BCD Output (Catalog No. 22974): A connector on the rear of the Instrument provides the numeric display in a BCD 1-2-4-8 code, with TTL/DTL compatible and positive logic.

a. Input/Output Logic Level:
   Logic "0"; 0V to +0.4V
   Logic "1"; +2.4V to +5.25V
b. Decimal Point Outputs:
   Logic "0" = ON
   Logic "1" = OFF
c. Print Command: Output signal to signify data ready at logic "1" level. Positive-going edge can be used to activate printing of BCD data.
d. Read Command: Input Signal to start a sampling cycle with a negative pulse applied (pulse width must be 200 $\mu$sec or greater).
e. Overrange:
   Logic "0" = ON
   Logic "1" = OFF

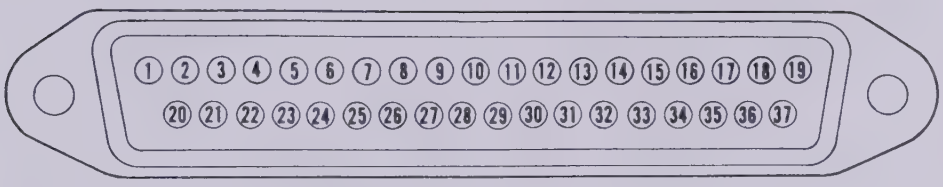
CAUTION

**All BCD outputs are non-buffered and only capable of driving 1 standard TTL load each. Any voltage or shorts applied to these outputs can cause damage to the internal circuitry of the Instrument.**

Table 1-1. Technical Data

| | | |
|---|---|---|
| **1. FREQUENCY** | | |
| **Frequency Range:** | 5 Hz to 50 MHz | |
| **Gate Time:** | 10 msec (0.1 kHz resolution) 0.1 sec., 1.0 sec., 10 sec., (0.1 Hz resolution) | |
| **Accuracy:** | ±1 count ± time base accuracy | |
| **2. ELAPSED TIME (Sec)** | | |
| **Display Range:** | 0.01 sec. to 19999.99 sec. (Based on overrange equals 1,000,000 counts) | |
| **Accuracy:** | ±1 count ± time base accuracy | |
| **3. TOTALIZE** | | |
| **Display Range:** | 1 to 1999999 (Based on 1,000,000 overrange) | |
| **Frequency Range:** | 5 Hz to 50 MHz | |
| **Accuracy:** | ±1 count | |
| **4. SELF TEST:** | Internal 100 kHz signal to test logic circuits and display | |
| **5. INPUT CHARACTERISTICS** | | |
| **INPUT (AC coupled)** | | |
| **Impedance:** | 1 MΩ shunted by 30 pF | |
| **Frequency Range:** | 5 Hz to 50 MHz | |
| **Sinewave Sensitivity:** | 50 mV RMS, from 5 Hz to 50 MHz | |
| **Maximum Input Voltage:** | 240V RMS, from 5 Hz to 100 kHz, derated to 50V RMS at 1 MHz, and 10V RMS at 50 MHz. | |
| **6. INTERNAL TIME BASE** | **7016** | **7016A (Option)** |
| **Frequency:** | 2.0 MHz | 2.0 MHz |
| **Temperature Stability:** | ±10 ppm maximum, 0°C to +45°C | ±1 ppm maximum, 0°C to +45°C |
| **Aging Rate** | ±5 ppm maximum per year | ±1 ppm maximum per year |
| **Stability With Line Voltage Variations:** | ±1 ppm for ±10% line voltage variation | ±0.1 ppm for ±10% line voltage variation |
| **7. EXTERNAL OSCILLATOR REQUIREMENTS** | | |
| **Frequency:** | 1 MHz square wave | |
| **Amplitude** | | |
| **Logic "1":** | +2.4V to +5V | |
| **Logic "0":** | 0V to +.4V | |
| **Output Drive:** | Standard TTL Logic compatibility | |
| **8. GENERAL** | | |
| **Display:** | 0.55-inch character height, 7-segment planar gas-discharge type, 6 digits | |
| **Display Storage:** | Selectable by front panel switch | |
| **Sample Rate:** | Continuously adjustable from 2 readings per second to hold. HOLD input on optional rear panel BCD output connector (see Figure 1-2), provides sampling by application of a negative pulse. | |
| **Reset:** | Front panel RESET pushbutton switch resets all decade counters and initiates new measurements. | |
| **9. TEMPERATURE RANGE** | | |
| **Operating:** | 0°C to +45°C | |
| **Storage:** | −40°C to +70°C | |
| **10. POWER REQUIREMENT:** | 120/240 VAC ±10%, 50, 60, 400 Hz; approximately 20VA | |
| **11. DIMENSIONS** | | |
| **Height:** | 4 in. (101.6 mm) | |
| **Width:** | 8.5 in. (215.9 mm) | |
| **Depth:** | 8 in. (203.2 mm) | |
| **12. WEIGHT:** | Approximately 6.5 lbs. (2.95kg) | |

AMPHENOL CONNECTOR
PART NO. 17-20370




37 CONTACTS

PIN IDENTIFICATION

NOTE: For reference see Figure 7-1 Schematic Diagram

| CONTACT NUMBER | BCD OUTPUT | CONTACT NUMBER | BCD OUTPUT |
|---|---|---|---|
| 1 | 6A | 20 | 5A |
| 2 | 6B | 21 | 5B |
| 3 | 6C | 22 | 5C |
| 4 | 6D | 23 | 5D |
| 5 | 4A | 24 | 3A |
| 6 | 4B | 25 | 3B |
| 7 | 4C | 26 | 3C |
| 8 | 4D | 27 | 3D |
| 9 | 2A | 28 | 1A |
| 10 | 2B | 29 | 1B |
| 11 | 2C | 30 | 1C |
| 12 | 2D | 31 | 1D |
| 13 | — | 32 | — |
| 14 | OVERRANGE | 33 | +5V |
| 15 | D.P. 1* | 34 | GND |
| 16 | D.P. 2 | 35 | PRINT COMMAND |
| 17 | D.P. 3 | 36 | — |
| 18 | D.P. 4 | 37 | READ COMMAND |
| 19 | D.P. 5 | — | — |

*Decimal points

Figure 1-2. BCD Output Connections

# SECTION II

# INSTALLATION

## 2.1 GENERAL

This section contains information pertaining to unpacking, inspection, installation, and power requirements for the electronic counter.

## 2.2 UNPACKING AND INSPECTION

Examine the shipping carton for obvious signs of damage prior to unpacking. If shipping carton is in good condition, then unpack and inspect the Instrument for possible damage incurred during shipment. If damage is noted, notify the carrier and supplier and do not attempt further use of the Instrument. If Instrument appears to be in good condition, read Operator's Manual in its entirety. Become familiar with the Instrument as instructed in the manual, then proceed to check the electrical performance as soon as possible. Also check that all items are included in the shipment (see Table 7-1).

## 2.3 POWER SOURCE REQUIREMENTS

The electronic counter can be operated from either a 120 or 240 volt, 50, 60, or 400 Hz AC power source. Primary power requirements are connected internally (see Figure 2-1), as indicated on the rear panel marking. The power requirement of the Instrument is approximately 20 VA.

CAUTION

**Do not connect the counter-timer to a power source until instructed to do so. Check that line voltage of your power source corresponds with requirement designated on the rear panel marking.**

## 2.4 MOUNTING INSTRUCTIONS

The Instrument can be set horizontally with the handle positioned along the top of the unit as shown in Figure 3-1, or to a convenient sloping position as shown in Figure 1-1. However, the unit will operate properly in any position.

## 2.5 ELECTRICAL PERFORMANCE

After proper completion of visual inspection and selection of an adequate power source, check the electrical performance of the electronic counter as soon as possible (refer to Maintenance Section VI).

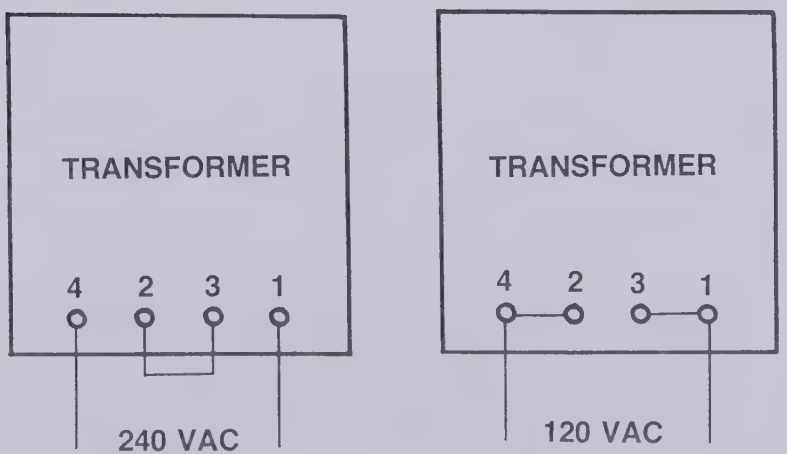



Figure 2-1. Internal AC Input Power Connections

# SECTION III

# CONTROLS, CONNECTORS AND INDICATORS

## 3.1 GENERAL

All operating and adjustment controls, connectors and indicators are described in Table 3-1. Become familiar with each item prior to operating the Instrument for the first time.

## 3.2 FRONT AND REAR PANEL DESCRIPTION

Table 3-1 lists all front and rear panel controls, connectors and indicators. See Figure 3-1.

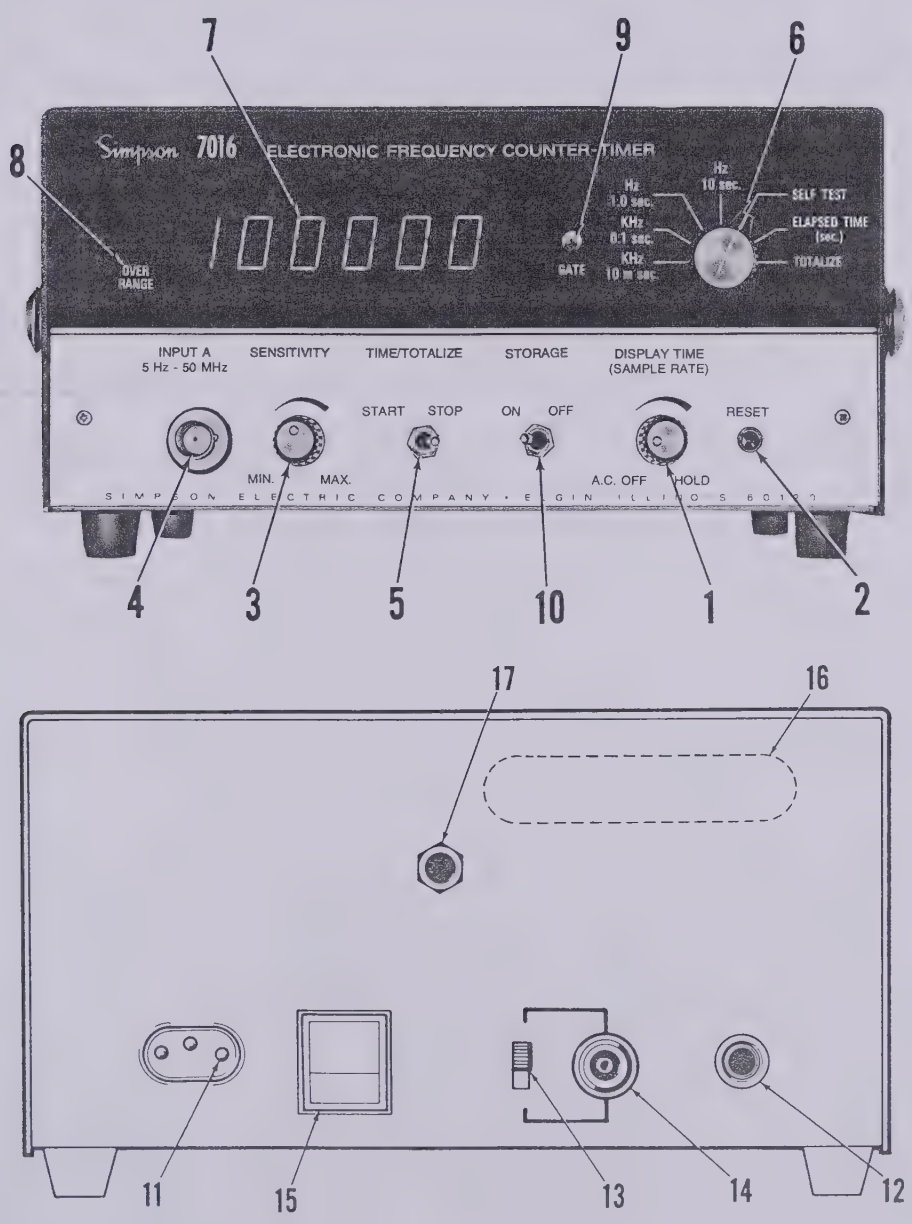



Figure 3-1. Front and Rear Panel, Controls, Connectors, and Indicators

## Controls, Connectors, and Indicators

**Table 3-1. Front and Rear Panel Description**

| | |
|---|---|
| 1. **DISPLAY TIME (SAMPLE RATE) Control:** | Applies primary power to the Instrument when the control is away from the AC OFF position, and varies the display time rate from 2 per second to HOLD position. |
| 2. **RESET Pushbutton Switch:** | Returns both displayed and internal count to zero and initiates a new sampling cycle. |
| 3. **SENSITIVITY Control:** | Attenuates the input signal for proper triggering level. Minimum attenuation is applied to the input signal when the control is set at the max. position. |
| 4. **INPUT 5 Hz-50 MHz Connector:** | Provides AC coupling to main amplifier. |
| 5. **TIME/TOTALIZE START-STOP Switch:** | Provides control when the selector switch is in the TOTALIZE position for totalizing measurements or in the ELAPSED TIME (sec) position for elapsed time measurement. |
| 6. **Selector Switch Position** | |
| a. **(FREQUENCY) POSITION:** | Permits measurement of average frequency applied to the input connector during a time interval selected by this switch. It provides 10 msec; 0.1 sec; 1 sec; or 10 sec. time base for measuring the average frequency. |
| b. **SELF TEST Position:** | Permits checking of internal logic circuit operation with an internal signal of 100 kHz with a fixed time base of 1 sec. |
| c. **ELAPSED TIME (sec) position:** | Permits measurement of an elapsed time period in one hundredth of a second resolution. |
| d. **TOTALIZE position:** | Permits counting of events applied to the INPUT connector. By using the START-STOP switch, control of the desired counting interval of events, or pulses is obtained. The RESET pushbutton switch must be pressed to start this function from a zero count. |
| 7. **Numeric Display Indicator:** | 7-segment planar display to indicate magnitude of the signal parameter being measured. |
| 8. **OVERRANGE Indicator:** | Illuminates when the measured signal value exceeds the full scale range (999999 counts). |
| 9. **GATE Indicator:** | Illuminates when the gate is open during a measurement cycle. |
| 10. **STORAGE Switch:** | Permits the displayed count to be held until the next measurement is complete (ON position) or continuously updated as each count is accumulated (OFF position). |
| 11. **AC POWER Connector:** | Connects to the AC line cord supplied with the Instrument. |
| 12. **REMOTE START-STOP Switch:** | Provides external control of the counter gate when in the TOTALIZE or ELAPSED TIME mode. When activated, it overrides the front panel START-STOP switch. |
| 13. **INT/EXT CLOCK Selector:** | Enables the Instrument to operate from either the internal oscillator (2 MHz) or an external clock source connected to the EXT CLOCK connector (BNC provided. For signal requirements, refer to specifications in Table 1-1, item 7. |
| 14. **EXT-CLOCK Connector:** | Provides connection to an external oscillator (clock). |
| 15. **LINE FUSE RECEPTACLE:** | AC power line fuse is retained by a snap-on cover. (See Table 7-2). |
| 16. ***BCD OUTPUT Connector:** | Provides the binary-coded-decimal outputs of all display decade counters and the data ready signal. |
| 17. **GROUND Jack:** | This terminal is electrically connected to the case and the AC line "third wire" ground. |

*Available as an option

# SECTION IV

# OPERATION

## 4.1 GENERAL

**WARNING**

**The Model 7016 is designed to prevent accidental shock when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to do so can result in a serious or fatal accident.**

The Model 7016 measures frequency, elapsed time and total events. The following contains all the information related to operation of the Instrument. Special notes and instructions have also been provided for added safety and convenience.

## 4.2 SAFETY PRECAUTIONS

**4.2.1** The Model 7016 is designed to be used only by personnel qualified to recognize shock hazards and trained in the safety precautions required to avoid possible injury. Refer to SHOCK HAZARD definitions on page iv.

**4.2.2** Do not work alone when making measurements where a shock hazard can exist. Notify a nearby person that you are, or intend to make such measurements.

**4.2.3** The Model 7016 is designed to operate from a 3-wire power line outlet that is wired and grounded in accordance with the latest National Electric Code. If not certain of the integrity of the outlet ground or if forced to connect to a 2-wire outlet, use a 3-wire to 2-wire plug adapter. Be sure to ground the adapter pig-tail lead to a known good earth ground for operator safety.

**4.2.4** Do not exceed the maximum input voltage ratings of the Model 7016 which are tabulated in Table 1-1. To do so endangers personal safety and may also damage the Instrument.

**4.2.5** Observe the correct polarity when making connections, as the input connector outer shell is grounded to the case and to the power line.

**4.2.6** Do not attempt to float the grounded terminals (the body of the BNC input connector which is electrically connected to the case) or the case of the Model 7016 above earth or power line ground. To do so risks personal safety and may damage the Model 7016 as well as the equipment under test.

**4.2.7** Remember, voltages might appear unexpectedly in defective equipment. An open bleeder resistor can result in a capacitor retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured before making connections or disconnections.

**4.2.8** Locate all voltage sources prior to making any connections. For your safety, do not touch leads, circuits, or the Instrument, while power is applied to the circuit being measured. Always inspect leads and connectors for cracks, breaks or crazes before each use. If any defects exist, replace the defective item immediately.

**4.2.9** Use extreme caution when making measurements in an rf circuit, where a dangerous combination of voltages could be present, such as in a modulated rf amplifier.

## 4.3 FREQUENCY MEASUREMENT PROCEDURE (See Figure 4-1)

a. **Review safety information in paragraph 4.1 and 4.2.**

b. Turn DISPLAY TIME (sample rate) control (1) clockwise from AC OFF position to turn Instrument on.

c. Set selector switch (2), to the desired (gate) time or time base.

d. Set CLOCK switch (see Figure 3-1) item 13 to INT position.

e. Connect signal being measured to INPUT connector, while the signal source is off.

f. Set SENSITIVITY control (3) to the most extreme ccw position that still gives a consistent reading.

g. Read frequency from display (4). Decimal point is correctly positioned, and correct measurement unit (Hz or kHz) is indicated by the selector switch position.

h. Set STORAGE switch (5) to ON position for a non-blinking display.

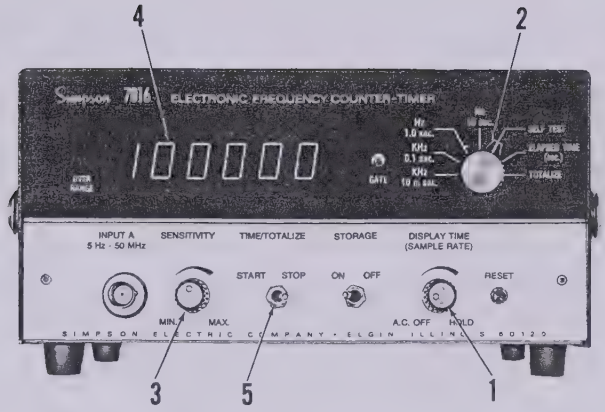



Figure 4-1. Frequency Measurement Controls

## 4.4 SELF TEST PROCEDURE (See Figure 4-2)

a. Turn DISPLAY TIME (sample rate) control (1) clockwise from AC OFF position to turn Instrument ON.

b. Set selector switch (2) to SELF TEST position.

c. Set CLOCK switch (see Figure 3-1 item 13) to INT. position.

d. Read 100000 Hz frequency from display (3). No decimal point will be displayed in the SELF TEST mode.

e. Set STORAGE (4) switch to ON position for a non-blinking display.

## 4.5 ELAPSED TIME MEASUREMENT PROCEDURE (see Figure 4-3)

a. **Review safety information in paragraph 4.1 and 4.2.**

b. Turn DISPLAY TIME (sample rate) control (1) clockwise, away from AC OFF position to HOLD position.

c. Set selector switch (2) to ELAPSED TIME position.

d. Set START-STOP switch (3) to STOP position.

e. Momentarily depress RESET pushbutton switch (4).

f. Start the count by setting the START-STOP switch (3) to START position.

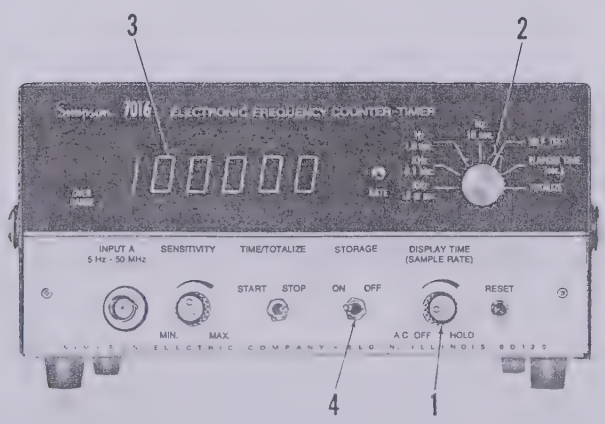



Figure 4-2. Self Test Controls and Procedure

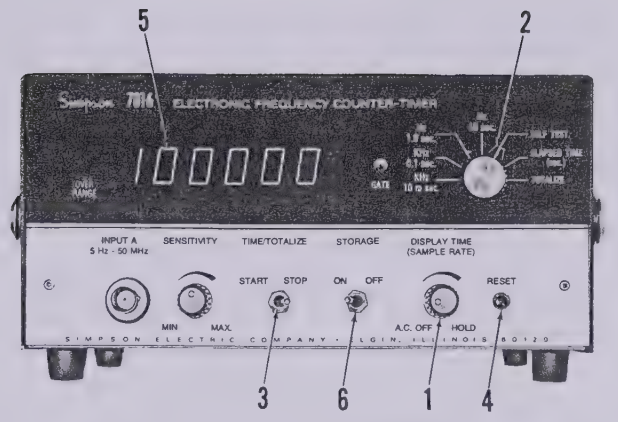



**Figure 4-3. Elapsed Time Measurement**

g. Stop the count by setting the START-STOP switch (3) to STOP position.

h. Read the total period of elapsed time in seconds from display (5). The decimal point will be displayed in the proper location.

i. Set STORAGE switch (6) to OFF position, if visual indication of count accumulation is desired.

## 4.6 TOTALIZE PROCEDURE (see Figure 4-4)

a. **Review safety information in paragraph 4.1 and 4.2.**

b. Turn DISPLAY TIME (sample rate) control (1) clockwise, away from AC OFF position to HOLD position.

c. Set selector switch (2) to TOTALIZE position.

d. Set START-STOP switch (3) to STOP position.

e. Connect event or pulse source to INPUT connector (4).

f. Momentarily depress RESET pushbutton switch (5).

g. Start the count by setting the START-STOP switch (3) to START position.

h. Stop the count by setting the START-STOP switch (3) to STOP position.

i. If counting does not start, set SENSITIVITY control (6) to a higher sensitivity position (CW), until counting starts. Repeat steps e, f, and g for each reading.

j. Read number of input events or pulses from display (7).

k. Set STORAGE switch (8) to OFF position if visual indication of count accumulation is desired.

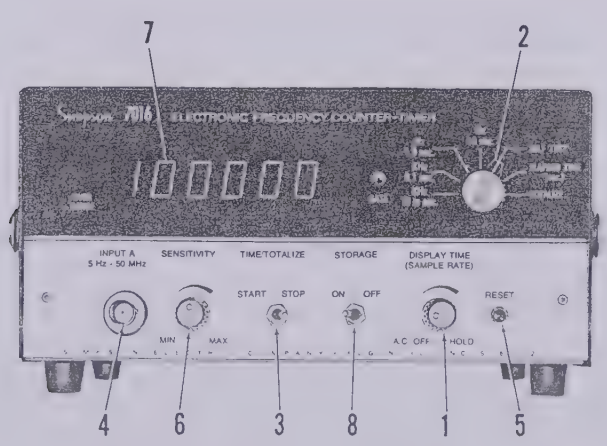



**Figure 4-4. Totalize Controls and Procedure**

## 4.7 APPLICATIONS

### 4.7.1 High Frequency Measurement by Prescaling

Direct measurement of frequency is one of the most useful applications of the Electronic Counter-Timer. By using a non-displaying frequency divider or prescaler (such as the Simpson Model 7020) to produce one output pulse for every 10 or 100 input pulses, and applying the output pulses to the Model 7016 input, it is possible to extend the counter range of the Model 7016 to above 500 MHz.

### 4.7.2 Totalizer

a. Totalizer (as the name implies), counts and provides a readout of the total number of pulses received without the use of a specific gate time. It can be used for counting events from the number of boxes coming off a production line to pulses from a nuclear particle detector. The gate time can be controlled by either using the START-STOP switch provided on the front panel, or the REMOTE START-STOP control (phone jack) provided on the rear panel.

b. When the REMOTE START-STOP control is used, it overrides the front panel control. The REMOTE START-STOP control can be activated by either an external S.P.D.T. switch or external electronic devices. Paragraph 6.8.2 describes the circuit connections to the switch. When interfacing with external electronic devices, do not apply more than +5 VDC or less than 0 VDC to the control gate IC 14 as shown in the following diagram.

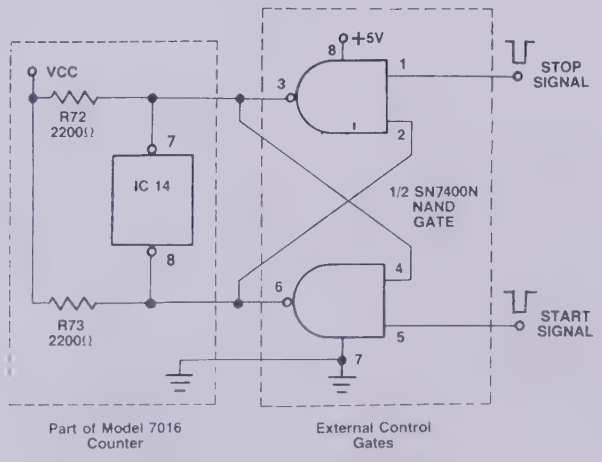



Figure 4-5. External Control for Totalize Measurement

### 4.7.3 RPM Measurements

The speed of a rotating mechanical component can be measured by using the Model 7016 Counter and a sensor to translate the mechanical movement into electrical signals, such as incremental shaft encoder, a proximity switch, or a photo-sensor. By prescaling the input with a factor of 60 for every resolution, the speed can be measured and displayed as RPM directly on the Model 7016 counter. An example is given below to demonstrate the use of a Simpson Model 410 Photo-Tachometer and the Model 7016 counter to measure the speed of a rotating plate.

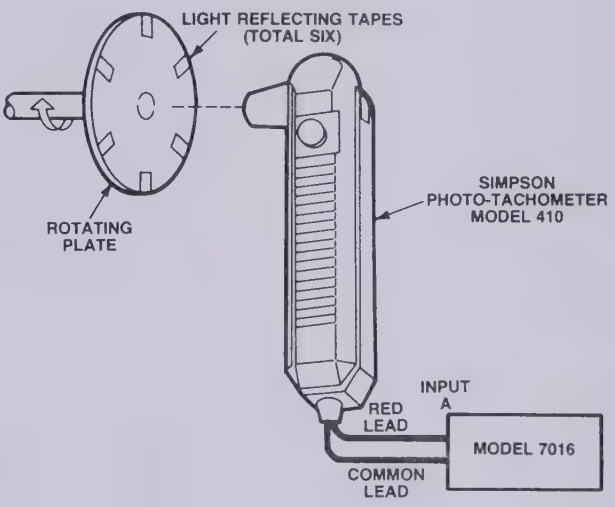



Figure 4-6. RPM Measurement

Example, RPM Measurements:
By applying six equally spaced light-reflecting tapes to the rotating plate, a total of six pulses will be picked up by the Simpson Model 410 Photo-Tachometer as shown in Figure 4-6. The output of the sensor is then fed to the Model 7016 input, operating in the FREQUENCY mode. Under these conditions, the Model 7016 display will indicate the unit "RPM X 10". As a typical application, consider the following example:

1. Speed of Rotating Plate = 1,000 revolutions per minute.

2. Frequency of pulses are applied to Input of 7016 = 6000 pulses per minute or 100 pulses per second.

If the 1 second time base on the Model 7016 is chosen, the displayed value will be: 100 (RPM X 10) or 1000 RPM.

If 60 light reflecting tapes are applied to the rotating plate, the Model 7016 will indicate "RPM" directly.

# SECTION V

# THEORY OF OPERATION

## 5.1 GENERAL

This section describes the theory of operation of the Model 7016. All modes of operation are described first; then, description of the circuits follows. Figure 5-1 shows the overall block diagram of the Instrument.

## 5.2 BASIC COUNTER CIRCUITS

**5.2.1** The basic counter circuits are arranged to provide several modes of operation. Each mode includes a "NAND" Gate with two inputs; a signal input A, and a control input B, or gating signal. Following the "NAND" Gate, is a cascaded series of decade counters (1, 10, 100, 1000, 10,000 and 100,000) which accumulate and display the total number of pulses passing through the Gate.

**5.2.2** The circuit sequence for the various modes of operation is similar. Pulses pass through the "NAND" Gate to the Decade Counters for a pre-determined time, are counted, stored, and displayed. The difference between the various modes are: (a) the source of the pulses counted, and (b) the source of the gating signal which establishes the length of time the Gate is open (to pass pulses to the Decade Counter).

## 5.3 FREQUENCY MEASUREMENT

This circuit arrangement (as shown in Figure 5-2, section A, −FREQUENCY) permits control of the Gate by the Decade Dividers which represent the time base. The Gate is opened for a controlled time; therefore, the accumulated count represents the number of input cycles or pulses during this time. Controlled intervals are from 10 seconds down to 10 milliseconds in decade submultiples, selectable with the front panel (selector) switch. The decimal point is automatically positioned, and the readout is in Hz, or kHz as indicated by the selector switch position.

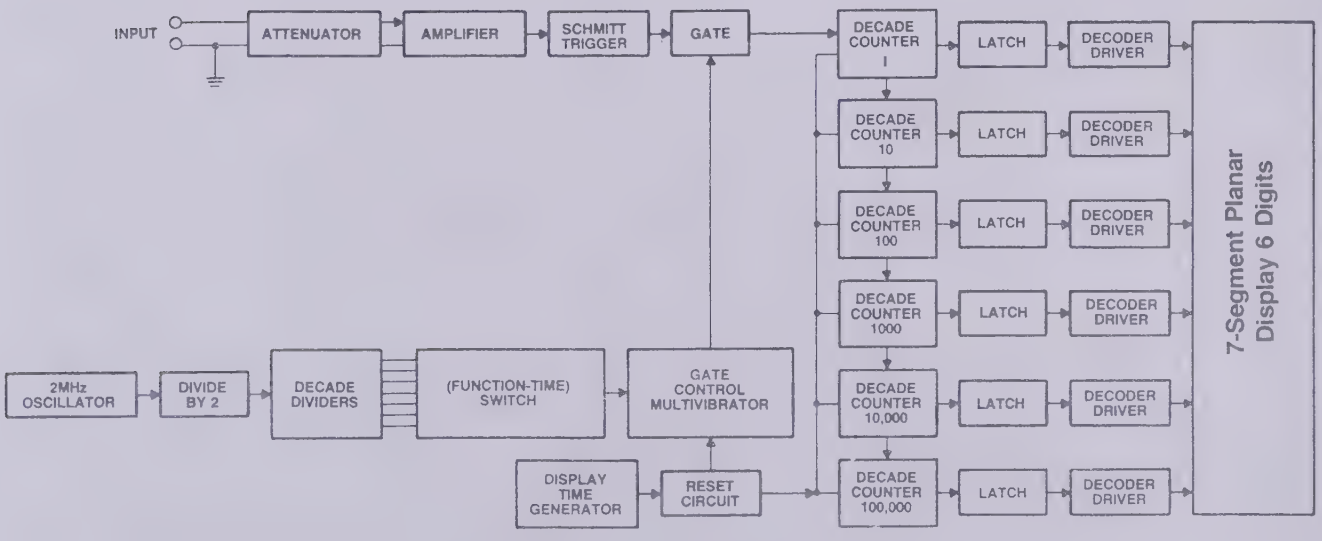



Figure 5-1. Block Diagram, Theory of Operation

## 5.4 ELAPSED TIME (Sec) MEASUREMENT

In the ELAPSED TIME (Sec) mode of operation (as shown in Figure 5-2, section B), the Gate is controlled by the TIME/TOTALIZE START-STOP switch, when the selector switch is in the ELAPSED TIME (Sec) position. The Gate is open when the START-STOP switch is in the START position, and closed when it is in the STOP position. An internal 10 msec signal is fed to the gate directly from the time base decade dividers and is counted and displayed while the Gate is opened. External control of the gate can be made through the rear panel REMOTE START-STOP control jack.

## 5.5 TOTALIZE

In the TOTALIZE mode of operation (as shown in Figure 5-2, section C TOTALIZE), the Gate is controlled by the TIME/TOTALIZE START-STOP switch, when the selector switch is in the TOTALIZE position. The Gate is open when the START-STOP switch is in the START position, and closed when it is in the STOP position. The number of pulses is counted and displayed while the Gate is opened. External control of the Gate can be made through the rear panel REMOTE START-STOP control jack.

## 5.6 AMPLIFIER (Figure 5-1)

Amplifier consists of a junction field-effect (high input impedance) transistor; AC coupled to a wide band, linear-integrated circuit amplifier. Through frequency compensation networks, sufficient gain is maintained for a frequency response of 5 Hz to 50 MHz. Input overload protection is provided by two silicon diodes at the input of the amplifier.

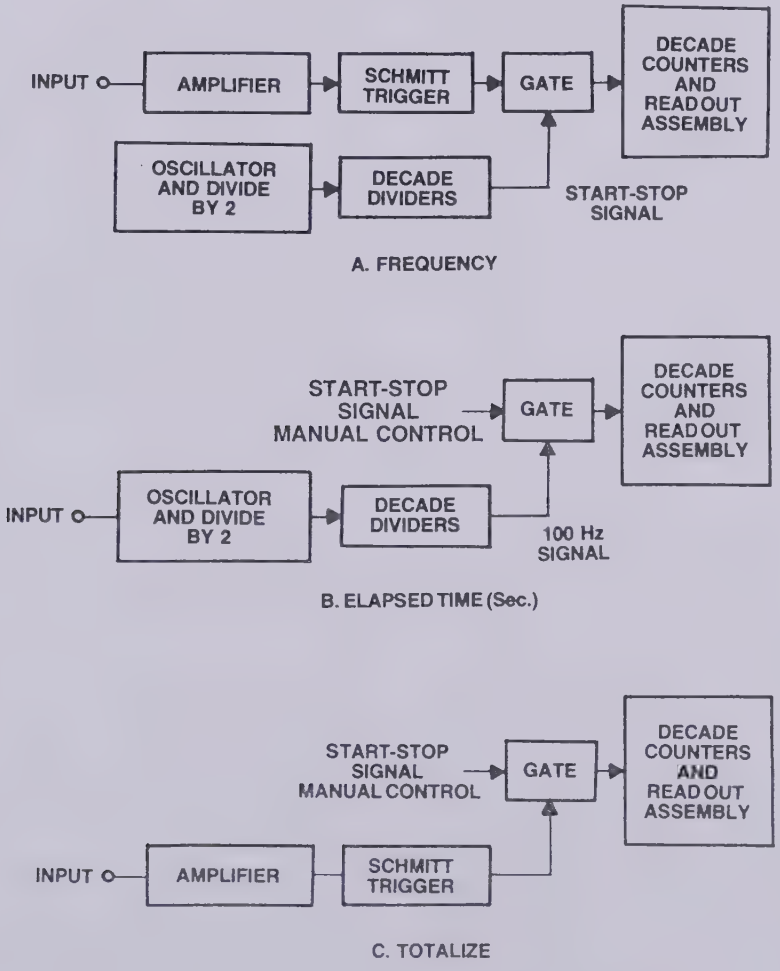



Figure 5-2. Block Diagram, Functional Modes

## 5.7 SCHMITT TRIGGER (Figure 5-1)

The amplifier is followed by the Schmitt Trigger Circuit consisting of two transistors and a level converter. This circuit, which triggers on positive going signals from the amplifier, shapes the input sine wave signal into a square-wave signal which is required for proper interface with the digital circuits.

## 5.8 2 MHz OSCILLATOR AND FREQUENCY DIVIDER

**5.8.1** The 2 MHz oscillator circuit is a crystal-controlled Colpitts oscillator, followed by an emitter follower and common-emitter switch for isolation and impedance matching. The Model 7016A contains a 1 ppm temperature compensated crystal oscillator circuit. The output frequency of the oscillator can be adjusted, if required, over a narrow range by means of a trimmer capacitor.

**5.8.2** The oscillator output is fed to the frequency divider and reduced in frequency to 1 MHz. The frequency divider is one-half of a dual J-K flip-flop, connected to provide division by 2.

## 5.9 DECADE DIVIDERS

Each of the seven Decade Dividers consists of a monolithic integrated circuit decade counter. The output of each Decade Divider is a square wave signal whose frequency is a submultiple of the 1 MHz output of the divide-by-two binary. The outputs derived from the dividers serve as time bases for the Instrument.

## 5.10 GATE AND GATE CONTROL CIRCUITS

**5.10.1** The Gate is a "NAND" gate which consists of a 2-input integrated circuit whose function is to control the input pulses to the Decade Counters. In frequency measurement, the signal being measured appears at one input. The time-base signal (duration selected by the selector switch), acts as the controlling elements, and appears at the other input.

**5.10.2** The Gate Control circuit performs the function of enabling and inhibiting the "NAND" gate, and is initiated by a pulse from the Reset Circuit. The output of the Gate control circuit comes from a bi-stable multivibrator ("flip-flop"). The input to the flip-flop is a square wave from the Decade Divider selected by the selector switch. The first negative going edge of the square wave "triggers" the flip-flop and causes its output to "open" the Gate circuit. The next negative going edge, which occurs at the end of one complete square wave cycle, returns the flip-flop to its initial state, closes the Gate and also inhibits the square wave input to the flip-flop until the next reset-START signal is received. In the TOTALIZE mode, the gate is controlled either by the front panel START-STOP switch or the rear panel REMOTE START-STOP control jack.

## 5.11 DISPLAY TIME GENERATOR

The Display Time Generator is a monolithic integrated circuit timer. The output frequency of the generator, adjustable with the front panel DISPLAY TIME (sample rate) control, initiates the Reset Circuit and determines the sampling rate of the unit.

## 5.12 RESET CIRCUIT

The Reset Circuit shapes and buffers the output pulse from either the Display Time Generator or the manual reset switch. This pulse drives the decade counters into their reset state. It also initiates the Gate Control Circuit to start a new sampling cycle.

## 5.13 DECADE COUNTERS

The monolithic integrated circuit decade counters totalize the pulses derived from the input signal, to provide a digital representation of the number of pulses. Each decade counter consists of four flip-flops. A combination of output levels from the flip-flops represents one of ten decimal digits when the binary-coded-decimal (BCD) weight 1, 2, 4, or 8 is assigned to the "one" state of each flip-flop. For example, if flip-flops A, B, C and D are weighted 1, 2, 4, and 8 respectively, and if A and D are in the "zero" state, and B and C are in the "one" state, the decimal digit represented is $0 + 2 + 4 + 0 = 6$. A total greater than 9 is not possible, because of the internal connections of the four flip-flops.

## 5.14 LATCHES

The monolithic integrated circuit latch performs the function of storing BCD data received from the Decade Counter and feeding the data to the Decoder/Driver from numerical display. Each latch consists of four shift-register type flip-flops. The storage feature of the latch is disabled when the STORAGE switch is in the OFF position.

## 5.15 DECODER/DRIVER

The monolithic integrated circuit Decoder/Driver performs two functions: (a) it converts the outputs of the latch from a binary number to a decimal number, and (b) serves as high voltage driver for the DISPLAY. Four lines of the BCD 1, 2, 4, and 8 are connected as inputs to each Decoder/Driver. The outputs consist of seven lines required to form numerals 0-9 on the 7-segment display. Illumination of a segment is activated by a low level output (0V) of the Decoder/Driver.

# SECTION VI

# MAINTENANCE

## 6.1 GENERAL

WARNING

**This Instrument contains internal voltages which constitute a SHOCK HAZARD. Review what constitutes a SHOCK HAZARD as explained on page iv. Internal adjustments or repairs shall be performed only by qualified personnel, preferably a Simpson Authorized Service Center.**

**6.1.1** The Model 7016 is carefully designed and constructed with high quality components. By providing reasonable care, and following the instructions in this manual, the user can expect a long useful service life from his Instrument.

**6.1.2** This section provides maintenance, calibration, performance checks and troubleshooting procedures for the Instrument. The procedures provided may be used:

a. As part of an incoming inspection check of Instrument specifications.

b. After any repairs or adjustments, before returning the Instrument to regular service.

c. Periodically, for instruments used in systems where maximum reliability is of utmost importance.

d. As part of a troubleshooting procedure to locate malfunctioning circuits.

## 6.2 WARRANTY

The Simpson Electric Company warranty policy is printed on the inside back cover of this manual. Read it carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact your nearest Authorized Service Center for instructions. These centers are listed on the last pages of this manual. If you wish to contact the factory directly, give full details of the difficulty and include the Instrument model number, serial number (at the back of the Instrument) and date of purchase. Service data or shipping instructions will be sent to you promptly. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will be quoted. This charge will not be exceeded without your prior approval.

## 6.3 SHIPPING

**6.3.1** Pack the Instrument carefully and ship it prepaid to the proper destination. Insure the shipment.

## 6.4 FUSE REPLACEMENT

a. Press on the bottom of the fuse receptacle cap at the back of the Instrument.

b. Remove cap and fuse, and replace with a fuse of the same rating (See Table 7-2).

c. Push fuse receptacle cap into the receptacle by applying pressure to the center of the cap until it locks itself into place.

CAUTION

**DO NOT replace a blown fuse with a fuse which has a larger rating or slower time lag characteristic than those specified (see Table 7-2).**

## 6.5 LINE VOLTAGE

During the performance checks, the Instrument shall be connected to a power source, through a variable voltage device. This procedure is to enable line voltage to be varied ±10% from 120 or 240 VAC, thus assuring satisfactory performance under various supply conditions.

## 6.6 REQUIRED TEST EQUIPMENT

Table 6-1 lists the recommended test equipment required for maintenance and calibration of the Instrument. Other comparable test equipment may be used, provided the specifications are equal, or better.

## 6.7 INSTRUMENT COVER REMOVAL

WARNING

**Remove all power and connections to the Instrument prior to removing the case cover.**

a. Rotate the DISPLAY TIME (sample rate) control to the AC OFF position.

b. Remove the two Phillips head screws near the front of each side of the cover and loosen the two rear screws.

c. Position the handle upright (top of case); then lift the front of cover upward, pull forward to clear rear screws and remove.

d. Reverse this procedure when replacing the cover.

## 6.8 PRINTED CIRCUIT COMPONENT REPLACEMENT

Component lead holes in the circuit board are plated through to ensure good electrical contact between conductors on the opposite sides of the board. To prevent damage to this plating and to the replacement component, apply heat sparingly and work carefully. The following replacement procedure is recommended.

a. Remove defective component.

b. Melt solder in component lead holes. Use clean dry soldering iron to remove excess solder. Clean holes with toothpick or wooden splinter. Do not use a metal tool for cleaning, as this may damage the hole plating.

c. Carefully bend the leads of the replacement component to the correct shape, and insert component into the component lead holes. Using heat and solder sparingly, solder leads in place. Heat may be applied to either side of board. A heat sink (long-nose pliers, commercial heat-sink tweezers, etc.) must be used when replacing semiconductors, in order to prevent conduction of excessive heat from the soldering iron to the component.

d. Hole plating breaks are indicated by the separation from the board of the round conductor pad on either side of the board. To repair breaks, press conductor pads against board, and solder replacement component lead to conductor pad on both sides of the board.

## 6.9 CALIBRATION

Refer to Table 6-1 for Test Equipment. To calibrate the Model 7016, perform the following procedure:

a. Plug Instrument into an appropriate power source, as indicated on rear panel marking. Turn power "on", and allow one hour warm-up for Model 7016 and 24 hour warm-up for 7016A. Units must have top and bottom covers in place during warm-up.

b. Set Instrument controls as follows (see Figure 3-1):

1. SENSITIVITY control to the MAX. position.
2. CLOCK switch (on rear panel) to INT position.
3. Selector switch to "Hz 10 sec" position.
4. On the Hewlett Packard Model 5245L (rear panel), set the MODE switch to INT STD FREQ position.
5. On the Hewlett Packard Model 5245L (rear panel), set the OUTPUT STD FREQ switch to 10 MHz position.

c. Connect the INPUT connector to the Hewlett Packard Model 5245L OUTPUT connector.

d. Using an insulated screw driver, adjust the trimmer capacitor, C28 (see Figure 6-1), which is accessible through the hole in bottom of case, so that unit reads 00000.0 ±10 counts with OVERRANGE indicator "on".

e. On Model 7016A, remove the top cover, and the screw-type plug on the crystal oscillator (see Figure 6-2). Adjust the trimmer (inside oscillator enclosure)

**Table 6-1. Recommended Test Equipment**

| INSTRUMENT TYPE | REQUIRED CHARACTERISTICS | MODEL RECOMMENDED |
|---|---|---|
| Frequency Counter | Frequency Range: 0 to 50 MHz<br>Period Range: 100 $\mu$s to 200 ms<br>Sensitivity: 50 mV RMS minimum<br>Accuracy: 1 part in $10^7$ | Hewlett Packard Model 5245L with 5261A Video Amplifier plug-in |
| Bridge Oscillator | Frequency Range: 500 kHz to 50 MHz<br>Output Level: 0 to 1 V RMS across 50 ohm load<br>Frequency Accuracy: ±10% | General Radio Type 1330A |
| Wide-Range Oscillator | Frequency Range: 5 Hz to 600 kHz<br>Output Level: 0 to 10 V RMS across 600 ohm load<br>Frequency Accuracy: ±10% | Hewlett Packard Model 200 CD |
| Oscilloscope | 50 MHz bandwidth, with dual-trace plug-in. | Tektronix 7403N with 7B53AN Dual Time Base and 7A18N Dual Trace Amplifier |

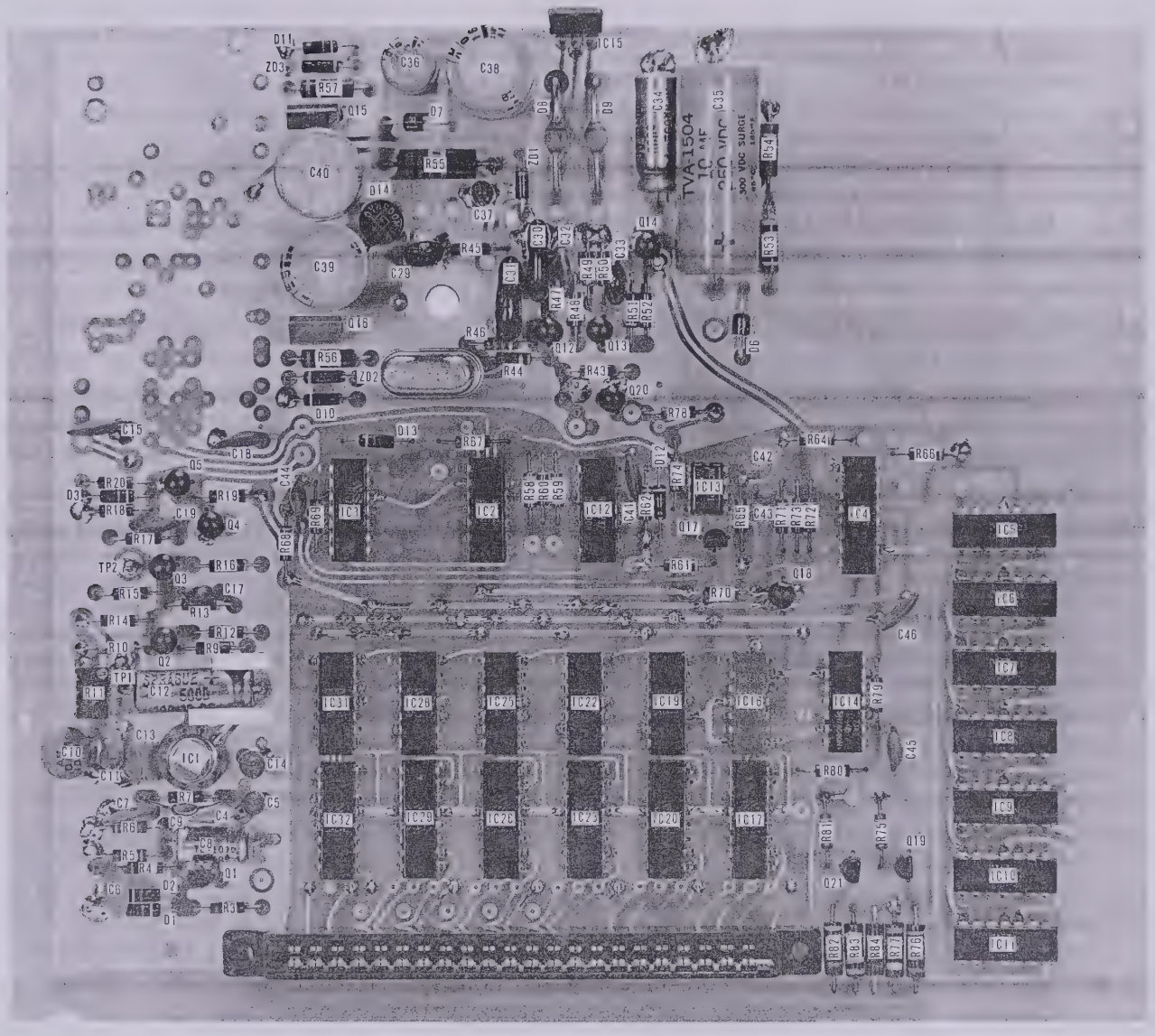


Figure 6-1. Printed Circuit Board Assembly-Main

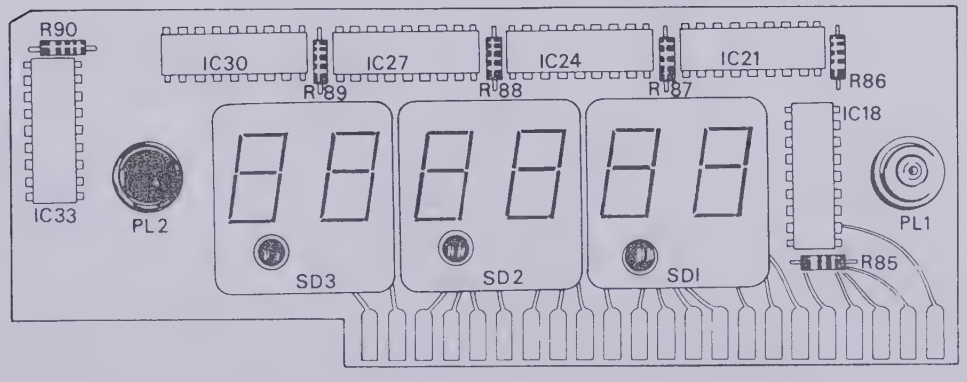



Figure 6-2. Printed Circuit Board Assembly-Readout

so that the unit reads 00000.0 ±1 count with the OVERRANGE indicator "on". The cover must remain off, for as short a period as possible while performing the adjustment.

f. If cover was removed (for Model 7016A), replace it and remove test leads from the unit.

## 6.10 PERFORMANCE CHECKS

The following performance checks are used to verify the specifications of the Instrument. They must be performed after completion of the calibration procedure outlined in paragraph 6.9.

### 6.10.1 High Frequency Measurement Check

Refer to Table 6-1 for Test Equipment.

a. Set the Instrument controls as follows:
   1. CLOCK switch (on rear panel) to INT. position.
   2. DISPLAY TIME (sample rate) control set slightly away from the AC OFF position.
   3. Selector switch to KHz 10 msec position.
   4. SENSITIVITY control to MAX. position.

b. Connect output of Bridge Oscillator to INPUT connector of Instrument, AC INPUT of Frequency Counter, and AC INPUT of Oscilloscope.

c. Adjust the Bridge Oscillator for an output signal of 50000.000 kHz ±.500 kHz, as indicated on the Frequency Counter, and an amplitude of 0.14 V P-P, as measured on the Oscilloscope.

NOTE: Observe that the reading on Model 7016 is between 49998.9 and 50001.1 and Model 7016A is between 49999.4 and 50000.6.

d. Vary the selector switch positions. The following readings (as shown in Table 6-2) must be displayed:

### 6.10.2 Low Frequency Measurement Check

Refer to Table 6-1 for Test Equipment.

a. Set the Instrument controls as follows:
   1. CLOCK switch (on rear panel) to INT position.
   2. DISPLAY TIME (sample rate) control set slightly away from the AC OFF position.
   3. Selector switch to Hz 1.0 sec position.
   4. SENSITIVITY control to the MAX position.

b. Connect output of Wide Range Oscillator to INPUT connector of Instrument, DC INPUT of Frequency Counter, and DC INPUT of Oscilloscope.

c. Adjust the Wide Range Oscillator for a signal of 10 Hz, as indicated in the Frequency Counter, and a level of not less than 0.14 V P-P as measured on the Oscilloscope.

NOTE: Observe that the reading is 10 ±1 Hz.

d. Repeat steps 1 through 4 of paragraph 6.10.2.a., above: for frequencies of 20, 30, 100 and 1000 Hz, with an amplitude of not less than 0.14 V P-P. The readout accuracy shall be 0.001% of reading ±1 digit. Readout accuracy for 7016A shall be 0.0001% of reading ±1 digit.

## 6.11 TOTALIZE MEASUREMENT CHECKS

Refer to Table 6-1 for Test Equipment.

### 6.11.1 Front Panel Control

a. Set the Instrument controls as follows:
   1. DISPLAY TIME (sample rate) control to HOLD position.
   2. Selector switch to TOTALIZE position.
   3. SENSITIVITY control to MAX. position.
   4. REMOTE START-STOP switch to STOP position.
   5. STORAGE switch to OFF position.

b. Connect output of Wide Range Oscillator to INPUT on Instrument.

c. Set controls on Wide Range Oscillator for a 10 Hz signal, and the AMPLITUDE control to mid-scale position (approx. 5 volts rms).

d. Momentarily depress RESET pushbutton switch. The count shall reset to zero.

e. Set REMOTE START-STOP switch to START position.

Table 6-2. High Frequency Display Indications Chart

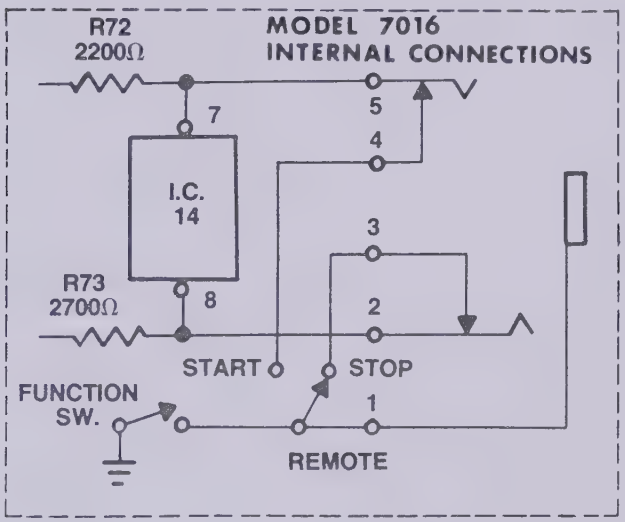
| POSITION OF SELECTOR SWITCH | MODEL 7016 | MODEL 7016A |
|---|---|---|
| Hz 10 sec | *98999.9 - *010001 | *99449.9 - *00550.1 |
| Hz 1.0 sec | *998999 - *001001 | *999449 - *000551 |
| KHz 0.1 sec | *9998.99 - *0001.01 | *9999.44 - *0000.56 |
| KHz 10 msec | 49998.9 - 50001.1 | 49999.4 - 50000.6 |

*Indicates OVERRANGE indicator on.

f. After a short period of time, set REMOTE START-STOP switch to STOP position. The counting will stop and the number indicated by the readout represents the number of cycles or pulses which have entered the counter within the start to stop period. The counting will continue to accumulate when the switch is again set to START.

### 6.11.2 REMOTE START-STOP (Rear Panel)

a. Use a Switchcraft 3-conductor type phone plug Part No. 60 or equivalent and connect the circuit to the plug as follows:



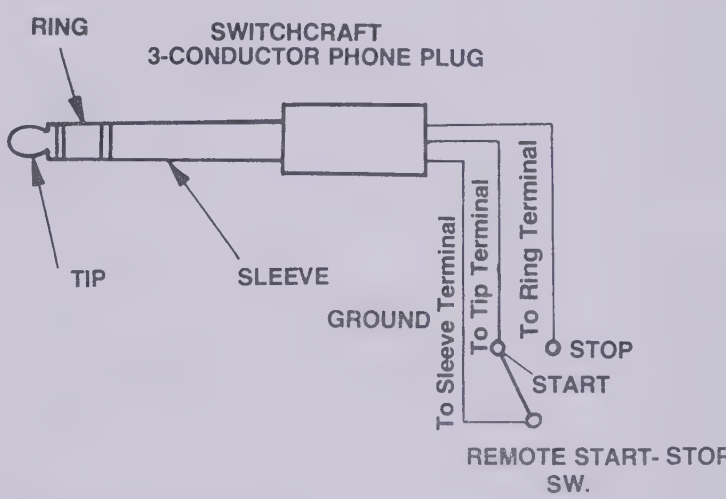




Figure 6-3. Remote Start-Stop Switch Connection Diagram

b. Insert the phone plug into the REMOTE START-STOP phone jack on the rear panel.

c. Repeat steps (a) through (f) of paragraph 6.11.1 by using the REMOTE START-STOP switch.

## 6.12 SELF TEST PROCEDURE

For SELF TEST procedure, refer to Section IV, paragraph 4.4.

## 6.13 TROUBLESHOOTING

### 6.13.1 Troubleshooting Aid

The following list of paragraphs, charts and illustrations is provided to aid in the troubleshooting of the Instrument.

a. Theory of operation — Section V.

b. Schematic diagrams — Section VII, Figure 7-1.

c. Block diagrams — Section V, Figures 5-1 and 5-2.

d. Troubleshooting chart — Section VI, Table 6-3.

e. Typical waveforms — Section VI, Figure 6-5.

f. Timing diagram — Section VI, Figure 6-4.

g. Typical power supply voltages — Section VI, Table 6-4.

h. Localizing diagram (SELF TEST MODE) — Section VI, Figure 6-6

### 6.13.2 Troubleshooting Chart

As a guide in troubleshooting, Table 6-3 outlines various malfunctions and probable causes of failure. During any stage in troubleshooting, inspect the Instrument for loose, burned or broken connections, and broken leads which might be the source of trouble.

## 6.14 TYPICAL POWER SUPPLY VOLTAGES AND RIPPLE

The list of typical power supply voltages and ripple in Table 6-4 is provided to further aid in Troubleshooting of the Instrument.

## 6.15 LOCALIZING DIAGRAM (SELF TEST MODE)

Figure 6-6 outlines the procedure for localizing the malfunction when the Instrument is operated in the SELF TEST mode.

a. Set Instrument controls as follows:

1. CLOCK switch (rear panel) to INT position.
2. Selector switch to SELF TEST position.

3. STORAGE switch to OFF position.
4. DISPLAY TIME (sample rate) control slightly away from AC OFF.

b. Refer to Schematic Diagram (Figure 7-1) for symbols.
c. Correct Indication — 100000.

**Table 6-3. Troubleshooting Chart**

| Malfunction | Probable Cause |
|---|---|
| 1. Display not illuminated | a. Instrument not plugged in<br>b. Line fuse blown (See Table 7-2)<br>c. Line switch<br>d. Power transformer connection<br>e. +200V supply |
| 2. No counting in SELF TEST mode of operation | a. Clock switch on rear panel<br>b. Control Gate IC 14<br>c. Control flip-flop IC 3 & 4<br>d. 2 MHz Oscillator<br>e. Oscillator Divider flip-flop IC4<br>f. Decade Dividers<br>g. Decade Counters<br>h. Decoder/Drivers<br>i. Selector switch<br>j. Latches |
| 3. Erroneous readout in SELF TEST mode of operation | a. Control flip-flops IC 3 & 4<br>b. Oscillator Divider flip-flop IC4<br>c. Decade Dividers<br>d. Decade Counters<br>e. Decoder/Drivers<br>f. Latches<br>g. Excessive ripple content on supply voltage (See Table 6-4) |
| 4. Instrument operates in SELF TEST mode, but does not function in FREQUENCY mode | a. Input connection<br>b. Sensitivity switch<br>c. Attenuator components<br>d. INPUT A Amplifier and/or Schmitt Trigger<br>e. +6.2V supply<br>f. −6.2V supply<br>g. +13V supply |
| 5. Instrument does not sample | a. IC 13 Timer<br>b. Reset Circuit<br>c. Control flip-flops IC 3 & 4<br>d. IC 2 Gates<br>e. Selector switch<br>f. Reset button |
| 6. Intermittent incorrect readout digit | a. Decoder/Driver<br>b. Decade Counter<br>c. +5V supply<br>d. +200V supply<br>e. Latches |
| 7. No reset to display | a. IC14 Gates<br>b. Reset Circuit<br>c. Decade Counters |

Table 6-4. Typical Power Supply Voltages

| POWER SUPPLY | *VOLTAGE | RIPPLE |
|---|---|---|
| **+5V CIRCUIT** | | |
| Pin #1 of IC 15 | 11V | 3V P-P |
| Pin #2 of IC 15 | 4.8 - 5.2V | 30 mV P-P |
| **+6.2V CIRCUIT** | | |
| Q16 collector | +13V | 4V P-P |
| Q16 base | +6.9V | 5mV P-P |
| Q16 emitter | +6.3V | 5mV P-P |
| **−6.2V CIRCUIT** | | |
| Q15 collector | −13V | 4V P-P |
| Q15 base | −6.9V | 5 mV P-P |
| Q15 emitter | −6.3V | 5 mV P-P |
| **+13V CIRCUIT** | | |
| 2D1 cathode | +13V | 75 mV P-P |
| **+200V CIRCUIT** | | |
| Junction of R53, R54, and C35 | +198V | 25V P-P |

*The above voltages are typical values and will vary with component tolerances and line voltage.

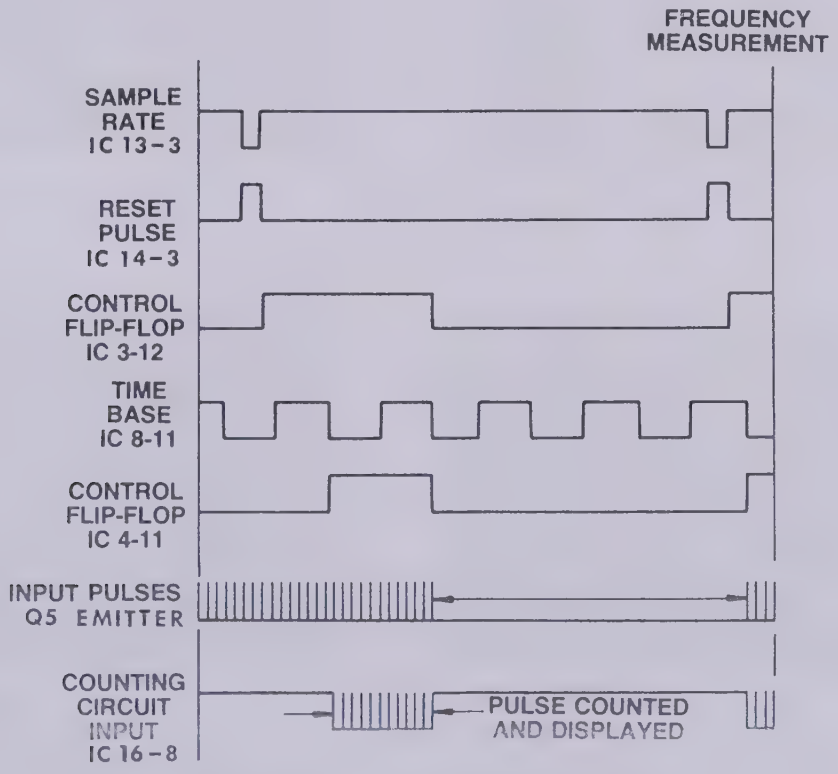
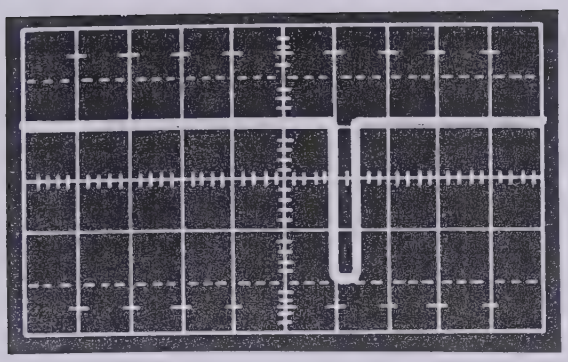
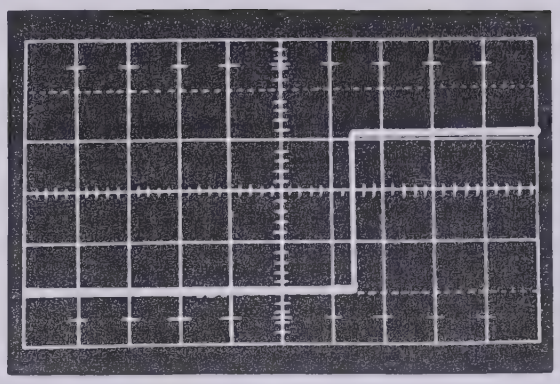


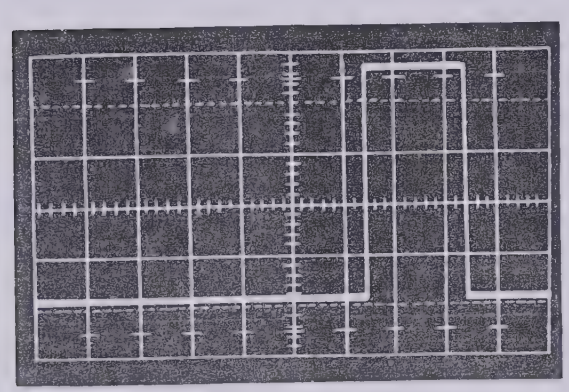

Figure 6-4. Timing Diagram (Frequency Measurement)



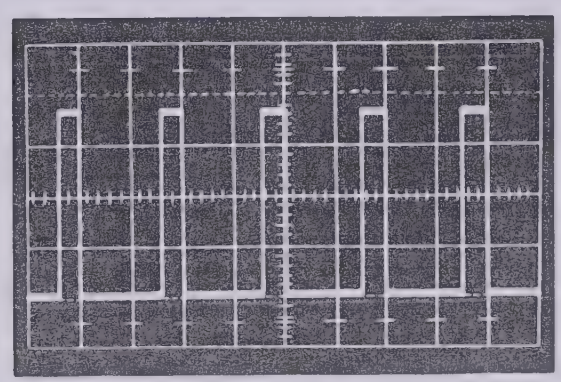
1. IC 13, Pin 3 Timer Output
   1msec/CM, 2V/CM (Scope Trigger)



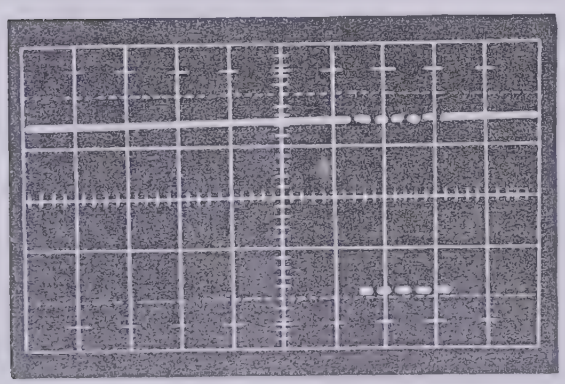
2. IC 3, Pin 12, Control Flip-Flop
   5msec/CM, 1V/CM



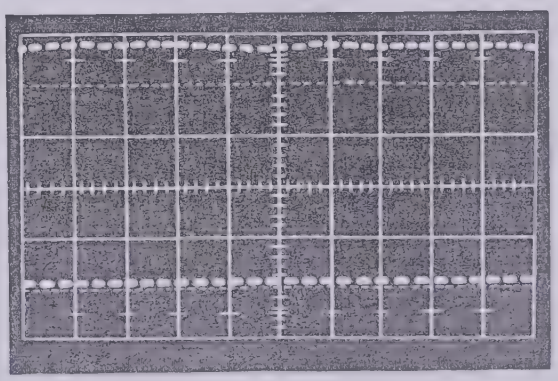
3. IC 8, Pin 11, 10m Sec. Time Base
   5msec/CM, 1V/CM



4. IC 4, Pin 11, Control Flip-Flop
   5msec/CM, 1V/CM



5. Q5, Emitter Input Pulses
   5msec/CM, 1V/CM



6. IC 16, Pin 8, Counting Circuit Input
   5msec/CM, 1V/CM

Figure 6-5. Typical Waveforms and Scope Settings

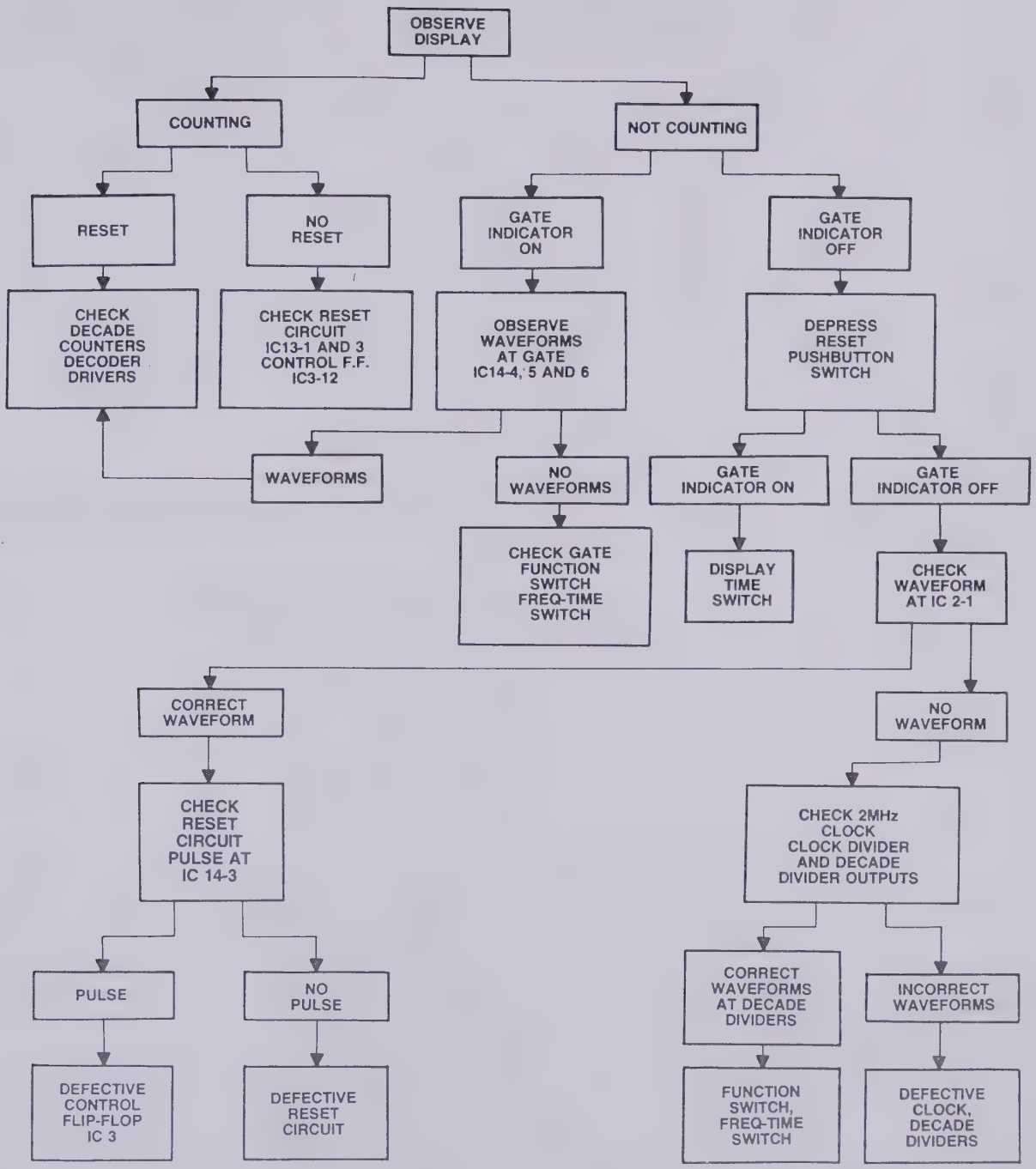



Figure 6-6. Localizing Diagram (Self Test Mode)

# SECTION VII

# ORDERING INFORMATION, SCHEMATIC DIAGRAM, AND AUTHORIZED SERVICE CENTERS

**Table 7-1. Items Furnished with Instrument**

| DESCRIPTION | NUMBER |
|---|---|
| Model 7016 Electronic Frequency Counter-Timer | 22970 |
| or | |
| Model 7016A Electronic Counter-Timer | 22972 |
| or | |
| Model 7016B Electronic Counter-Timer | 22974 |
| Probe Assembly, Zero Loss, with BNC Connector, Female | 10-830238 |
| Power Cord, Interconnecting, two 3-wire connectors, male on one end, female on opposite end | 5-112790 |
| Operator's Manual | 5-117381 |

**Table 7-2. Accessories Available**

| DESCRIPTION | NUMBER |
|---|---|
| Replacement Probe | 00238 |
| Fuse: (120 VAC) 1/2A, 250V type 3AG, slow blow | * |
| (240 VAC) 1/4A, 250V type 3AG, slow blow | |

*Available at local retail electronic outlets.

**Table 7-3. Replacement Parts List**

| Symbol | Description | Part No. |
|---|---|---|
| C1 | Capacitor, .47 μF, 250V | 5-113614 |
| C2 | Capacitor, 120 pF, 500V | 5-111432 |
| C3 | Capacitor, 15 pF, 1000V | 5-114989 |
| C4 | Capacitor, 0.01 μF, 50V | 5-113215 |
| C5 | Capacitor, 15 μF, 16V Electrolytic | 5-115534 |
| C6 | Capacitor, 0.01 μF, 50V | 5-113215 |
| C7 | Capacitor, 0.1 μF, 10V | 5-113214 |
| C8 | Capacitor, 20 μF, 6V, Electrolytic | 5-115024 |
| C9 | Capacitor, 15 pF, 1000V | 5-114989 |
| C10 | Capacitor, 0.01 μF, 50V | 5-113215 |
| C11 | Capacitor, 15 μF, 16V Electrolytic | 5-115534 |
| C12 | Capacitor, 100 μF, 12V Electrolytic | 5-114997 |
| C13 | Capacitor, 0.01 μF, 50V | 5-113215 |
| C14 | Capacitor, 15 μF, 16V Electrolytic | 5-115534 |
| C15 | Capacitor, 0.1 μF, 10V | 5-113214 |
| C17 | Capacitor, 560 pF, 500V | 5-112695 |
| C18 | Capacitor, 0.1 μF, 10V | 5-113214 |
| C19 | Capacitor, 100 pF, 1kV | 5-113217 |

| Symbol | Description | Part No. |
|---|---|---|
| C20 - C27 | (Not Used) | |
| C28* | Capacitor, Trimmer, 1.0-24pF | 5-115000 |
| C29* | Capacitor, 22pF, 500V | 5-114990 |
| C30* | Capacitor, 820pF, 500V | 5-114995 |
| C31* | Capacitor, 680pF, 500V | 5-114994 |
| C32* | Capacitor, 100pF, 1kV | 5-113217 |
| C33* | Capacitor, 220pF, 500V | 5-114992 |
| C34* | Capacitor, 100 $\mu$F, 12V Electrolytic | 5-114997 |
| C35 | Capacitor, 10 $\mu$F, 250V, Electrolytic | 5-113887 |
| C36 | Capacitor, 100 $\mu$F, 25V, Electrolytic | 5-117343 |
| C37 | Capacitor, 15 $\mu$F, 16V Electrolytic | 5-115534 |
| C38 | Capacitor, 1000 $\mu$F, 16V, Electrolytic | 5-117344 |
| C39 | Capacitor, 1000 $\mu$F, 16V, Electrolytic | 5-117344 |
| C40 | Capacitor, 1000 $\mu$F, 16V, Electrolytic | 5-117344 |
| C41 | Capacitor, .47 $\mu$F, 16V | 5-115530 |
| C42 | Capacitor, 1.0 $\mu$F, 16V Electrolytic | 5-115531 |
| C43 | Capacitor, 1.0 $\mu$F, 16V Electrolytic | 5-115531 |
| C44 | Capacitor, 0.001 $\mu$F, 500V | 1-119959 |
| C45 | Capacitor, 0.001 $\mu$F, 500V | 1-119959 |
| C46 | Capacitor, 0.1 $\mu$F, 10V | 5-113214 |
| D1 | Diode, Silicon 1N914 | 5-112004 |
| D2 | Diode, Silicon 1N914 | 5-112004 |
| D3 | Diode, Silicon 1N914 | 5-112004 |
| D4, D5 | (Not Used) | |
| D6 | Diode, Silicon 10D8 | 5-114006 |
| D7 | Diode, Silicon 10D1 | 5-114005 |
| D8 | Diode, Silicon A15F | 5-115475 |
| D9 | Diode, Silicon A15F | 5-115475 |
| D10 | Diode, Silicon 1N456A | 5-114946 |
| D11 | Diode, Silicon 1N456A | 5-114946 |
| D12 | Diode, Silicon 1N914 | 5-112004 |
| D13 | Diode, Silicon 1N914 | 5-112004 |
| D14 | Diode, Silicon W005 | 5-115945 |
| IC1 | I.C., Video Amplifier | 5-114937 |
| IC2 | I.C., Quad 2-Input Gate | 5-114943 |
| IC3 | I.C., J-K Flip-Flop | 5-114942 |
| IC4 | I.C., J-K Flip-Flop | 5-114941 |
| IC5 | I.C., Decade Counter | 5-114939 |
| IC6 | I.C., Decade Counter | 5-114939 |
| IC7 | I.C., Decade Counter | 5-114939 |
| IC8 | I.C., Decade Counter | 5-114939 |
| IC9 | I.C., Decade Counter | 5-114939 |
| IC10 | I.C., Decade Counter | 5-114939 |
| IC11 | I.C., Decade Counter | 5-114939 |
| IC12 | I.C., Quad 2-Input Gate | 5-114943 |
| IC13 | I.C., Timer | 5-117150 |
| IC14 | I.C., Schottky, Hi-Speed | 5-117146 |
| IC15 | I.C., +5V Voltage Regulator | 5-117149 |
| IC16 | I.C., Hi-Speed Decade Counter | 5-117147 |
| IC17 | I.C., Quad Latch | 5-117145 |

*Not used on Model 7016A

| Symbol | Description | Part No. |
|---|---|---|
| IC18 | I.C., 7-segment high voltage decoder/driver | 5-117148 |
| IC19 | I.C., Decade Counter | 5-114939 |
| IC20 | I.C., Quad Latch | 5-117145 |
| IC21 | I.C., 7-segment high voltage decoder/driver | 5-117148 |
| IC22 | I.C., Decade Counter | 5-114939 |
| IC23 | I.C., Quad Latch | 5-117145 |
| IC24 | I.C., 7-segment high voltage decoder/driver | 5-117148 |
| IC25 | I.C., Decade Counter | 5-114939 |
| IC26 | I.C., Quad Latch | 5-117145 |
| IC27 | I.C., 7-segment high voltage decoder/driver | 5-117148 |
| IC28 | I.C., Decade Counter | 5-114939 |
| IC29 | I.C., Quad Latch | 5-117145 |
| IC30 | I.C., 7-segment high voltage decoder/driver | 5-117148 |
| IC31 | I.C., Decade Counter | 5-114939 |
| IC32 | I.C., Quad Latch | 5-117145 |
| IC33 | I.C., 7-segment high voltage decoder/driver | 5-117148 |
| Q1 | Transistor 2N5458 | 5-112747 |
| Q2 | Transistor 2N4275 | 5-115008 |
| Q3 | Transistor 2N4275 | 5-115008 |
| Q4 | Transistor 2N4275 | 5-115008 |
| Q5 | Transistor 2N4275 | 5-115008 |
| Q6 - Q11 | (Not Used) | |
| Q12* | Transistor, 2N4275 | 5-115008 |
| Q13* | Transistor, 2N4275 | 5-115008 |
| Q14* | Transistor, 2N4275 | 5-115008 |
| Q15 | Transistor D41D1 | 5-117103 |
| Q16 | Transistor D40D1 | 5-117342 |
| Q17 | Transistor MPS3702 | 5-113864 |
| Q18 | Transistor 2N4275 | 5-115008 |
| Q19 | Transistor 2N6221 | 5-112632 |
| Q20 | Transistor 2N4275 | 5-115008 |
| Q21 | Transistor 2N6221 | 5-112632 |
| R1 | Resistor, 100 kΩ, ±10%, 1/2W | 1-113949 |
| R2 | Potentiometer, 1 MΩ | 5-117340 |
| R3 | Resistor, 100Ω, ±10%, 1/4W | 5-114968 |
| R4 | Resistor, 4.7KΩ, ±10%, 1/4W | 5-113873 |
| R5 | Resistor, 5.6KΩ, ±10%, 1/4W | 5-114975 |
| R6 | Resistor, 5.6KΩ, ±10%, 1/4W | 5-114975 |
| R7 | Resistor, 267Ω, ±1%, 1/4W | 5-114952 |
| R9 | Resistor, 3.74KΩ, ±1%, 1/4W | 5-114958 |
| R10 | Resistor, 1.96KΩ, ±1%, 1/4W | 5-114957 |
| R11 | Resistor, Variable, 200Ω | 5-117339 |
| R12 | Resistor, 113Ω, ±1%, 1/4W | 5-114950 |
| R13 | Resistor, 301Ω, ±1%, 1/4W | 5-114954 |
| R14 | Resistor, 270Ω, ±1%, 1/4W | 5-114953 |
| R15 | Resistor, 267Ω, ±1%, 1/4W | 5-114952 |
| R16 | Resistor, 430Ω, ±1%, 1/4W | 5-114955 |
| R17 | Resistor, 301Ω, ±1%, 1/4W | 5-114954 |
| R18 | Resistor, 120Ω, ±1%, 1/4W | 5-114951 |
| R19 | Resistor, 267Ω, ±1%, 1/4W | 5-114952 |

*Not used on Model 7016A

| Symbol | Description | Part No. |
|---|---|---|
| R20 | Resistor, 301Ω, ±1%, 1/4W | 5-114954 |
| R21 - R42 | (Not Used) | |
| R43* | Resistor, 270Ω, ±10%, 1/4W | 5-114969 |
| R44* | Resistor, 33KΩ, ±10%, 1/4W | 5-113875 |
| R45* | Resistor, 39KΩ, ±10%, 1/4W | 5-114979 |
| R46* | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R47* | Resistor, 3.3KΩ, ±10%, 1/4W | 5-114973 |
| R48* | Resistor, 22KΩ, ±10%, 1/4W | 5-113623 |
| R49* | Resistor, 39KΩ, ±10%, 1/4W | 5-114979 |
| R50* | Resistor, 3.9KΩ, ±10%, 1/4W | 5-114974 |
| R51* | Resistor, 47KΩ, ±10%, 1/4W | 5-114980 |
| R52* | Resistor, 1.5KΩ, ±10%, 1/4W | 5-113872 |
| R53 | Resistor, 470Ω, ±10%, 1/2W | 5-113940 |
| R54 | Resistor, 220Ω, ±10%, 1/2W | 5-111116 |
| R55 | Resistor, 150Ω, ±5%, 2W | 1-116445 |
| R56 | Resistor, 390Ω, ±10%, 1/2W | 1-115946 |
| R57 | Resistor, 390Ω, ±10%, 1/2W | 1-115946 |
| R58 | Resistor, 4.7KΩ, ±10%, 1/4W | 5-113873 |
| R59 | Resistor, 4.7KΩ, ±10%, 1/4W | 5-113873 |
| R60 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R61 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R62 | Resistor, 470Ω, ±10%, 1/4W | 1-116372 |
| R63 | Potentimeter, 1MΩ, 1/5W | 5-117340 |
| R64 | Resistor, 330KΩ, ±10%, 1/4W | 5-115965 |
| R65 | Resistor, 100Ω, ±10%, 1/4W | 5-114968 |
| R66 | Resistor, 1MΩ, ±10%, 1/4W | 5-113626 |
| R67 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R68 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R69 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R70 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R71 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R72 | Resistor, 2.2KΩ, ±10%, 1/4W | 5-113625 |
| R73 | Resistor, 2.2KΩ, ±10%, 1/4W | 5-113625 |
| R74 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R75 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R76 | Resistor, 22KΩ, ±10%, 1/2W | 1-113439 |
| R77 | Resistor, 68KΩ, ±10%, 1/2W | 1-114803 |
| R78 | Resistor, 510Ω, ±5%, 1/4W | 5-114965 |
| R79 | Resistor, 4.7KΩ, ±10%, 1/4W | 5-113873 |
| R80 | Resistor, 4.7KΩ, ±10%, 1/4W | 5-113873 |
| R81 | Resistor, 1KΩ, ±10%, 1/4W | 5-113871 |
| R82 | Resistor, 22KΩ, ±10%, 1/2W | 1-113439 |
| R83 | Resistor, 68KΩ, ±10%, 1/2W | 1-114803 |
| R84 | Resistor, 2.2KΩ, ±10%, 1/2W | 1-113941 |
| R85 | Resistor, 15KΩ, ±5%, 1/4W | 5-116134 |
| R86 | Resistor, 15KΩ, ±5%, 1/4W | 5-116134 |
| R87 | Resistor, 15KΩ, ±5%, 1/4W | 5-116134 |
| R88 | Resistor, 15KΩ, ±5%, 1/4W | 5-116134 |
| R89 | Resistor, 15KΩ, ±5%, 1/4W | 5-116134 |
| R90 | Resistor, 15KΩ, ±5%, 1/4W | 5-116134 |

*Not used on Model 7016A

| Symbol | Description | Part No. |
|---|---|---|
| XTAL | Oscillator Crystal, 2MHz (7016) | 5-115001 |
| XTAL | Oscillator, Crystal 2MHz (7016A) | 5-116239 |
| ZD1 | Diode, Zener 1N4743A | 5-112726 |
| ZD2 | Diode, Zener IR69-7534 | 5-114947 |
| ZD3 | Diode, Zener IR69-7534 | 5-114947 |
| PL1 | Capsule, Neon, Clear, P.P. | 5-112273 |
| PL2 | Capsule, Neon, Red, P.P. | 5-113331 |
| | Lamp, Neon, HE-2H | 5-111505 |
| | Board, P.C., 6-digit readout | 5-117316 |
| | Readout, 7-segment, 2 digit, P.P. | 5-117151 |
| | Connector, 2-digit readout | 5-117217 |
| | Spacer, Neon Lamp Holder | 5-117355 |
| | Transformer, Power | 5-117359 |
| | Knob, Round | 5-117361 |
| | Knob, Round, Black, Pointer, with Alum. Insert | 5-115583 |
| | Connector, BNC (Front Panel) | 5-117385 |
| | Switch, Pushbutton SPDT | 5-113222 |
| | Connector, BNC (Rear Panel) | 5-111622 |
| | Switch, Rotary, Function-Time | 5-117319 |
| | Switch, Toggle, SPDT | 5-113330 |

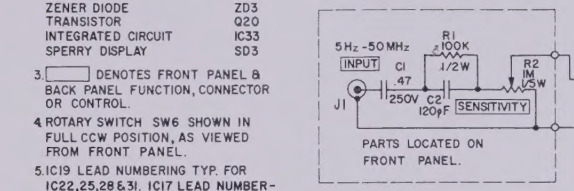
NOTES:

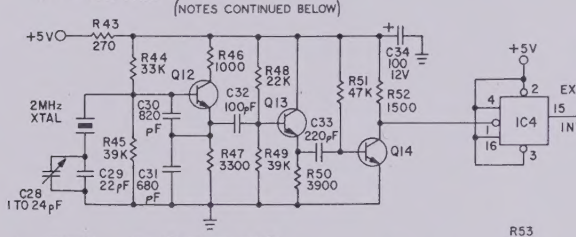
1. UNLESS OTHERWISE SPECIFIED:
   RESISTORS IN OHMS 1/4W 10%
   CAPACITORS IN μF
2. LAST COMPONENT NUMBERS:

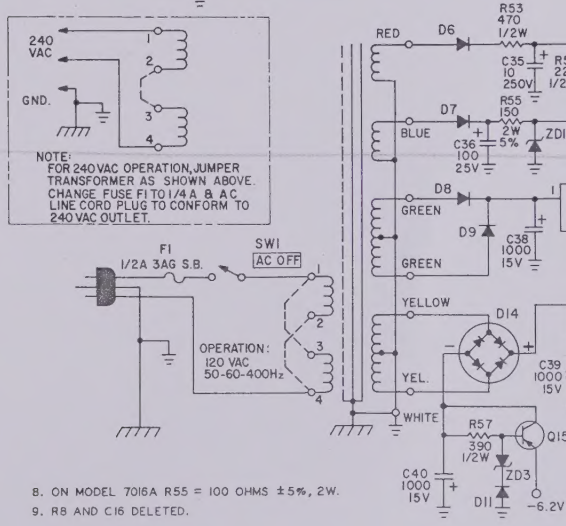
| | |
|---|---|
| RESISTOR | R90 |
| CAPACITOR | C46 |
| DIODE | D13 |
| ZENER DIODE | ZD3 |
| TRANSISTOR | Q20 |
| INTEGRATED CIRCUIT | IC33 |
| SPERRY DISPLAY | SD3 |

3. [ ] DENOTES FRONT PANEL & BACK PANEL FUNCTION, CONNECTOR OR CONTROL.
4. ROTARY SWITCH SW6 SHOWN IN FULL CCW POSITION, AS VIEWED FROM FRONT PANEL.
5. IC19 LEAD NUMBERING TYP. FOR IC22,25,28 & 31. IC17 LEAD NUMBERING TYP. FOR IC 20,23,26,29 & 32. IC18 LEAD NUMBERING TYP. FOR IC21, 24,27,30 & 33.
6. ⊗ DENOTES WIRING POINTS FOR BCD OUTPUT CONNECTOR. (SEE CHART "B")
7. TP — TEST POINT

(NOTES CONTINUED BELOW)




8. ON MODEL 7016A R55 = 100 OHMS ±5%, 2W.
9. R8 AND C16 DELETED.

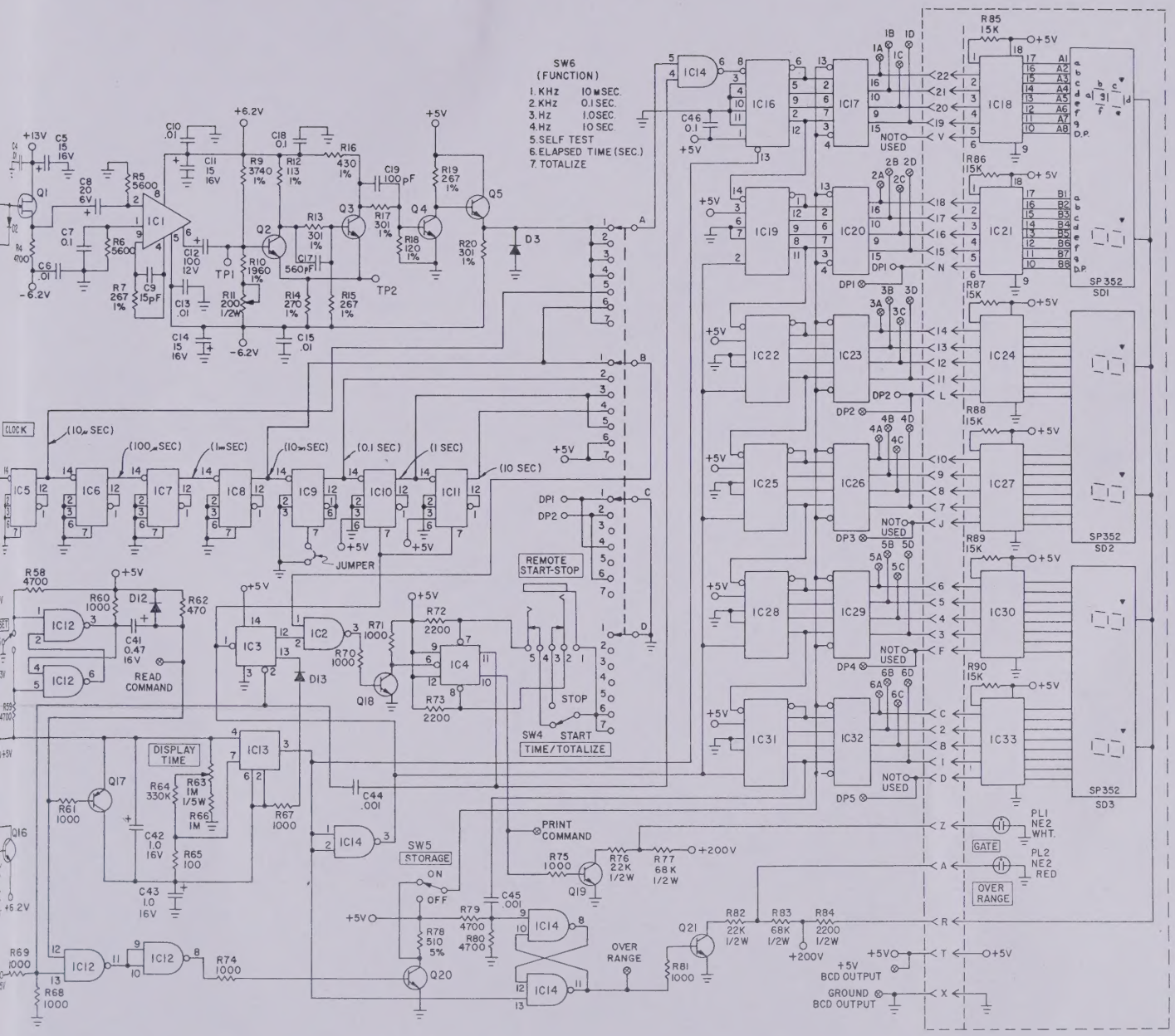
| ZENER DIODE COMPLEMENT | |
|---|---|
| ZD1 | IN4743A |
| ZD2 | IN753 ±1% |
| ZD3 | IN753 ±1% |

| DIODE COMPLEMENT | |
|---|---|
| D1 | IN914 |
| D2 | IN914 |
| D3 | IN914 |
| D4 | NONE |
| D5 | NONE |
| D6 | 100 8 |
| D7 | 1001 |
| D8 | A15F |
| D9 | A15F |
| D10 | IN456A |
| D11 | IN456A |
| D12 | IN914 |
| D13 | IN914 |
| D14 | W005 |

| TRANSISTOR COMPLIMENT | | | |
|---|---|---|---|
| Q1 | 2N5458 | Q12 | 2N4275 |
| Q2 | 2N4275 | Q13 | 2N4275 |
| Q3 | 2N4275 | Q14 | 2N4275 |
| Q4 | 2N4275 | Q15 | D41D1 |
| Q5 | 2N4275 | Q16 | D40D1 |
| Q6 | NONE | Q17 | MPS3702 |
| Q7 | NONE | Q18 | 2N4275 |
| Q8 | NONE | Q19 | 2N6221 |
| Q9 | NONE | Q20 | 2N4275 |
| Q10 | NONE | Q21 | 2N6221 |
| Q11 | 2N4275 | | |

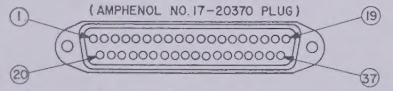
| INTEGRATED CIRCUIT COMPLEMENT | | | |
|---|---|---|---|
| IC1 | LM733 | IC18 | DM8884AN |
| IC2 | SN7400N | IC19 | SN7490N |
| IC3 | SN7473N | IC20 | SN7475N |
| IC4 | SN7476N | IC21 | DM8884AN |
| IC5 | SN7490N | IC22 | SN7490N |
| IC6 | SN7490N | IC23 | SN7475N |
| IC7 | SN7490N | IC24 | DM8884AN |
| IC8 | SN7490N | IC25 | SN7490N |
| IC9 | SN7490N | IC26 | SN7475N |
| IC10 | SN7490N | IC27 | DM8884AN |
| IC11 | SN7490N | IC28 | SN7490N |
| IC12 | SN7400N | IC29 | SN7475N |
| IC13 | NE555 | IC30 | DM8884AN |
| IC14 | N74S00A | IC31 | SN7490N |
| IC15 | μA7805 | IC32 | SN7475N |
| IC16 | N82S90A | IC33 | DM8884AN |
| IC17 | SN7475N | | |

| POWER AP | |
|---|---|
| IC # | + |
| 2 & 12 | |
| 3 | |
| 4 | |
| 5 THRU 11, 19, 22, 25, 28 & 31 | |
| 13 | |
| 14 | |
| 16 | |
| 17, 20, 23, 26, 29 & 32 | |
| 18, 21, 24, 27, 30 & 33 | |




| CHART "A" | | |
|---|---|---|
| ICD TO DIPS | | |
| VCC | GROUND | TYPE # |
| 14 | 7 | SN7400N |
| 14 | 11 | SN7473N |
| 5 | 13 | SN7476N |
| 5 | 10 | SN7490 |
| 8 | 1 | NE555 |
| 14 | 7 | N74S00A |
| 14 | 7 | N82S90A |
| 5 | 12 | SN7475N |
| 16 | 9 | DM8884AN |

OPTIONAL: BCD OUTPUT CONNECTOR
(AMPHENOL NO. 17-20370 PLUG)




| CHART "B" (OPTIONAL) | | | | | |
|---|---|---|---|---|---|
| BCD OUTPUT CONNECTOR | | | | | |
| CONTACT NUMBER | BCD OUTPUT | CONTACT NUMBER | BCD OUTPUT | CONTACT NUMBER | BCD OUTPUT |
| 1 | 6A | 14 | O.R. ⊛ | 27 | 3D |
| 2 | 6B | 15 | D.P.1 ✱ | 28 | 1A |
| 3 | 6C | 16 | D.P.2 ✱ | 29 | 1B |
| 4 | 6D | 17 | D.P.3 ✱ | 30 | 1C |
| 5 | 4A | 18 | D.P.4 ✱ | 31 | 1D |
| 6 | 4B | 19 | D.P.5 ✱ | 32 | —— |
| 7 | 4C | 20 | 5A | 33 | +5V |
| 8 | 4D | 21 | 5B | 34 | GND |
| 9 | 2A | 22 | 5C | 35 | PRINT COMMAND |
| 10 | 2B | 23 | 5D | 36 | —— |
| 11 | 2C | 24 | 3A | 37 | READ COMMAND |
| 12 | 2D | 25 | 3B | | |
| 13 | —— | 26 | 3C | | |

Figure 7-1. Model 7016 , Schematic Diagram